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Embargo Policy

Outcomes of Intracorporeal Urinary Diversion after Robot-Assisted Radical Cystectomy: Results from the International Robotic Cystectomy Consortium

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Abstract

Introduction and Objective: This study aims to provide an update and compare perioperative outcomes and complications of Intracorporeal urinary diversion (ICUD) and extracorporeal urinary diversion (ECUD) following RARC from a multi-institutional, prospectively maintained database, the International Robotic Cystectomy Consortium (IRCC).

Methods: A retrospective review of 2125 patients from 26 institutions was performed. ICUD was compared with ECUD Multivariate (stepwise variable selection) logistic regression models were fit to evaluate preoperative, operative, and postoperative predictors of receiving ICUD, operative time, high grade complications and 90-days readmissions after RARC.

Results: 51% (n=1094) patients underwent ICUD in our cohort. ICUD patients demonstrated shorter operative times (357 vs 400 minutes, p<0.001), less blood loss (300 vs 350 ml, p<0.001), and fewer blood transfusions (4% vs 19%, p<0.001). ICUD patients experienced more high grade complications (13 vs 10%, p=0.02). Utilization of ICUD increased from 9% of all urinary diversions in 2005 to 97% in 2015. Complications after ICUD decreased significantly over time (p<0.001). On multivariable analysis, higher annual cystectomy volume (OR 1.02, 95% CI (1.01-1.03), p<0.002) and year of RARC 2013-2016 (OR 68, 95% CI 44-105, p<0.001) and ASA score <3 (OR 1.75, 95% CI 1.38-2.22, p<0.001) were associated with receiving ICUD. ICUD was associated with shorter operative time (27 minutes, p=0.001).

Conclusion: Utilization of ICUD has increased over the past decade. Higher annual institutional volume of RARCs was associated with performing ICUD. ICUD was associated with shorter operative times. Although ICUD was associated with higher grade complications compared to ECUD, they decreased over time.

Introduction

Utilization of robot-assisted radical cystectomy (RARCs) has witnessed a paramount increase in the past decade (1). While RARC has been associated with improved perioperative outcomes such as blood loss, hospital stay, and improved convalescence, much of the criticism has been attributed lack of tactile feedback and the longer operative time, especially with intracorporeal approach to urinary diversion and also with construction of a continent reservoir. Consequently, most surgeons performed a hybrid approach with extracorporeal construction of urinary diversion.

Expertise and continuous refinement of the technique has cut down both operative times and costs (2). Consequently, operative time has been identified as a quality measure for surgical performance for RARC (3, 4). In a recent study, RARC and intracorporeal ileal conduit has been shown to be technically feasible and without jeopardizing outcomes (3, 5). On the other hand, intracorporeal neobladders are more technically challenging, time-consuming with steep learning curve and thereby they have been slower to adopt, and only confined to high volume academic institutions. Nevertheless, several techniques for intracorporeal neobladders have been recently described with promising functional and oncologic outcomes (6-9).

Intracorporeal urinary diversion (ICUD) provides benefits in terms of a complete minimally invasive technique, including smaller incisions, reduced pain, decreased bowel-related complications, and reduced risk of third space losses and fluid imbalances (10, 11). This study aims to provide an update and compare perioperative outcomes and complications of ICUD and extracorporeal urinary diversion (ECUD) following RARC from a multi-institutional, prospectively maintained database, the International Robotic Cystectomy Consortium (IRCC).

Methods

A retrospective review of 2432 patients from 29 institutions included in the IRCC database (I-97906) was performed. Patients who had missing data about the diversion approach or technique were excluded from the study. The final cohort comprised 2125 patients from 26 institutions who were treated with RARC since 2005. Data were reviewed for age, gender, body mass index [BMI], American Society of Anesthesiologists [ASA] score, preoperative characteristics (neoadjuvant chemotherapy, prior abdominal surgery, and clinical staging), institutional volume, year of RARC, operative variables (type and technique of diversion, operative time, estimated blood loss, and blood transfusion), perioperative outcomes (complications, readmissions, hospital and intensive care unit stay), and pathologic outcomes (staging, lymph node yield and soft tissue surgical margins). Technique of RARC and urinary diversion, and follow up differed among institutions. ICUD was compared with ECUD in terms of complications, survival, and patterns of recurrence.

Descriptive statistics were used to summarize the data. Univariable associations were statistically assessed using Wilcoxon Rank-Sum, Pearson Chi-square or Fisher's Exact test. Univariate and multivariate (stepwise variable selection) logistic regression models were fit to evaluate preoperative, operative, and postoperative predictors of receiving ICUD, operative time, high grade complications and any readmission after RARC. The Kaplan Meier method was used to depict recurrence-free (RFS), disease specific (DSS) and overall survival (OS). Cox proportional hazards regression models were fit to evaluate predictors of survival outcomes. All tests were two-sided, with statistical significance defined as $p \leq 0.05$. All statistical analyses were performed using SAS software (version 9.4, SAS Institute Inc., Cary, NC).

Results

Fifty-one percent (n=1094) patients underwent ICUD. Utilization of ICUD increased from 9% of all urinary diversions in 2005 to 97% in 2016, with a rate of increase of 11%/year (Figure 1). This increase has been primarily demonstrated for intracorporeal ileal conduits (increased from 2% in 2005 to 81% in 2016) and to a lesser extent for intracorporeal neobladders (from 7% in 2005 to 17% in 2016) (Figure 2). US institutions started to utilize ICUD more frequently in 2009 (22% of all diversions), and increased to 91% in 2015. In contrast, European institutions adopted ICUD earlier in their robotic experience (40% of all diversion in 2008 and reached 100% in 2016) (Figure 3).

Compared to patients who received ECUD, ICUD patients included fewer patients with ASA score ≥3 (44% vs 53%, $p<0.001$), and received neoadjuvant chemotherapy more frequently (25% vs 17%, $p<0.001$). ICUD patients demonstrated shorter operative times (357 vs 400 min, $p<0.001$), less blood loss (300 vs 350 ml, $p<0.001$) and received blood transfusion less frequently (5% vs 13%, $p<0.001$). There was no significant difference in terms of receiving neobladders (21% vs 23%, $p=0.32$). ICUD patients experienced complications more often (57% vs 43%, $p<0.001$) especially within the first month after RARC (31 vs 19%, $p<0.001$). However, the incidence of high grade complications after ICUD decreased significantly over time (from 25% in 2005 to 6% in 2015, $p<0.001$), and remained stable for ECUD (13% in 2005 and 14% in 2015, $p=0.76$) (Figure 4). ECUD showed more overall readmissions (34% vs 26%, $p=0.003$) (Table 1).

Both groups were comparable in terms of ≥pT3 disease (38% vs 39%, $p=0.59$), positive nodal disease (18% vs 19%, $p=0.51$), lymph node yield (11 vs 12, $p=0.90$) and positive soft tissue surgical margins (7% each, $p=0.71$). ECUD patients experienced more distant recurrences

(18% vs 14%, p=0.005), but less extrapelvic lymph node metastasis (1% vs 3%, p=0.01) and peritoneal carcinomatosis (0.3% vs 1.3%, p=0.01) (Table 2).

On multivariable analysis, higher annual RARC volume (Odds ratio [OR] 1.02, 95% Confidence Interval [CI] (1.01-1.03), p=0.002), year of RARC 2013-2016 (OR 68, 95% CI 44-105, p<0.001) and ASA score<3 (OR 1.75, 95% CI 1.38-2.22, p<0.001) were associated with receiving ICUD (Table 3). On the other hand, shorter operative time was associated with older age (1 minute shorter for each 1 year increase in age, p<0.001), annual cystectomy volume (1 minute shorter per 1 case increase in annual RARC volume, p=0.01), date of RARC (2013-2016 vs 2005-2008) (23 minutes shorter, p=0.01) and ICUD (27 minutes shorter, p<0.001). On the other hand, BMI (estimate of 4 minutes longer for each 1 Kg/m2, p<0.001), ASA ≥3 (22 minutes longer, p<0.001) and receiving a neobladder (64 minutes longer, p<0.001) were associated with longer operative time (Table 4).

History of prior abdominal surgery (OR 1.52 95% CI 1.06-2.15, p=0.02) was the only significant factor associated with high grade complications. Higher BMI (OR 1.05, 95% CI 1.02-1.07, p=0.0002), high grade complications (OR 2.22, 95 %CI 1.56-3.15, p<0.0001) were significantly associated with any readmission after RARC (Table 5).

Both groups exhibited similar RFS and DSS (Log rank p= 0.97 and 0.80, respectively). However, ICUD experienced worse OS (85%, 62% and 49% vs 85%, 69% and 58% at 1, 3 and 5 years, respectively) (log rank p=0.05) (Figure 5). For RFS, patients with ≥pT3 (HR 3.51, 95%CI 2.76-4.45, p<0.001) and pN+ (HR 2.72, 95%CI 1.81-2.86, p<0.001) had worse RFS, while RARCs performed 2009-2013 (HR 0.72, 95% CI 0.57-0.92, p=0.03) demonstrated better RFS when compared to RARCs performed 2005-2009. For DSS, patients with higher lymph node yield demonstrated marginal benefit (HR 0.97, 95% CI 0.96-0.99, p=0.01), while patients with positive soft tissue surgical margins (HR 1.66, 95% CI 1.07, 2.56, p=0.02), ≥pT3 (HR 5.63, 95% CI 3.89-8.13, p<0.001) and pN+ disease (HR 2.18, 95% CI 1.58-3.01, p<0.001) demonstrated worse DSS. For OS, high grade complications (HR 1.55, 95% CI 1.14-2.11, p=0.006), ASA≥3 (HR 1.36, 95% CI 1.10-1.70, p=0.005), positive margins (HR 1.46, 95% CI 1.06-2,.00, p=0.02), ≥pT3 (HR 3.52, 95% CI 2.73-4.54, p<0.001) and pN+ (HR 1.78, 95% CI 1.39-2.29, p<0.001) were associated with worse OS. Patients with neobladders had better OS (HR 0.49, 95% CI 0.30-0.70, p<0.001) (Table 6).

Discussion

Much of the criticism for ICUD has been attributed to the steep learning curve and longer operative time, especially if an orthotopic bladder substitute is planned. Our data shows that utilization of ICUD has increased over the past decade, reaching 97% in 2015 among IRCC members. This is contrast with prior reports that showed limited use of ICUD in the US (3% of RARCs) (12). Predictors of receiving ICUD were annual RARC volume, as well as cystectomy era (2013-2016) and ASA score < 3. It is notable that ICUD was adopted earlier in Europe when compared to the US (4). Prior reports showed that a stepwise approach to RARC and PLND allowed safe incorporation of ICUD (3). The technique of RARC, extended pelvic lymph node dissection (PLND) has been optimized, and as with experience in human-robot interaction, ICUD became more popular with development of multiple techniques for more complex intracorporeal neobladders (7, 9, 10, 13-15). A team approach combined with mentoring, especially during the early learning curve, will further reduce operative time and complications (16). Although there was no significant difference in the diversion type between ICUD and ECUD, the increase in utilization of ICUD has been primarily demonstrated for ileal conduits

(2% in 2005 to 81% in 2016) when compared to intracorporeal neobladders (from 7% in 2005 to 17% in 2016). Intracorporeal neobladder is more technically demanding and this may explain this pattern. Whether the approach to urinary diversion affects the decision for urinary diversion choice is still unclear(17).

With increased experience and comfort with the robotic platform, operative times for RARC have decreased over time (18). ICUD was associated with shorter operative time in this study in contrast to prior reports (11). This could be either due to increased comfort and experience with ICUD and flattening of the learning curve, or due to the additional time of undocking of the robot and preparing the patient for ECUD, which adds to the total operative time. Higher BMI, and neobladders may add to the complexity of RARC, with more time spent in port placement, careful dissection as well as LND (19, 20). Filson et al examined the different factors that may contribute to operative times and divided them into modifiable (such as extent of LND, diversion type and technique) and non-modifiable factors (such as age, gender in addition to institutional and surgeon factors) (21). They observed longer operative times with neobladders and with more extensive LNDs. Older age and the number of comorbidities were significantly associated with shorter operative times, which they explained by that surgeons anticipate higher anesthetic complications and tend to be faster in older and sicker patients. Female gender was also associated with longer operative times, which may be attributed to prior gynecologic procedures rather than a true gender-related difference (20). Higher annual RARC volume and more recent cystectomy era were associated with shorter operative time. More experience and flattening of the learning curve associated with more procedures performed would lead to cutting down of operative times. Similar to this study, higher surgical volume has been associated with shorter operative times for RC (21-23).

In an earlier report from IRCC (ICUD n=167, 18%), ICUD was associated with lower gastrointestinal and 90-day complication rates (11). The current study shows that patients who received ICUD had higher overall and high grade complications, especially within the first month after RARC. We believe that earlier experience was subject to patient selection bias. With increased utilization of ICUD and broadening of the patient selection, the actual burden of RARC, rather than ICUD, was observed (4). Interestingly, the incidence of high grade complications after ICUD decreased over time, while it remained stable for ECUD. Moreover, on multivariable analysis prior abdominal surgery was the only significant predictor of high grade complications. The presence of higher BMI and high grade complications were significantly associated with readmissions. The approach to urinary diversion (ICUD vs ECUD) was not a significant predictor of neither. About two-thirds of complications necessitating reoperations following RARC occur beyond 3 months of RARC. Therefore, it is important to report readmissions and complications beyond 3 months to avoid underestimation of the actual burden of the procedure (24).

There was significant difference between both approaches in terms of RFS or DSS. In agreement with the robotic and open cystectomy literature, survival outcomes after cystectomy are mainly driven by disease-related factors, including pT stage, nodal status and positive surgical margins (25-28). Patients with ECUD experienced more distant recurrences when compared to ICUD. In agreement with a prior report from IRCC, the incidence of peritoneal carcinomatosis and port site recurrences are low (1% and 0.3%, respectively) (26). Despite the statistical difference between ICUD and ECUD in extrapelvic lymph node metastasis and peritoneal carcinomatosis, the small numbers limit any conclusions that can be made. Patients with ECUD experienced better OS at 3 and 5 years, likely because of the higher complication rate associated with ICUD especially early in the ICUD experience. Nevertheless, diversion approach was not significantly associated OS. Patients who received neobladders had better OS likely because of patient selection bias rather than a true benefit of the urinary diversion type. Younger patients with fewer comorbidities and more favorable disease are more likely to be offered orthotopic bladder substitutes, and therefore more likely to have better survival outcomes (29).

To our knowledge, this is largest reported series of ICUD. However, several limitations exist. The inherent limitations to retrospective analysis should be acknowledged. The variability among institutions in the IRCC in terms of surgical technique, institutional follow up protocols and pathology reporting, and lack of detailed complications and comorbidity data apart from that presented are other limitations (supplementary tables 1 and 2). IRCC includes mainly high volume institutions and experienced surgeons, which may limit the generalizability of the results.

Conclusion

Utilization of ICUD has dramatically increased over the past decade. Higher annual institutional volume of RARCs was associated with performing ICUD. ICUD was associated with shorter operative times. Although ICUD was associated with higher grade complications compared to ECUD, they decreased over time. More surgeons are incorporating ICUD as part of their RARC with standardization and evolution of the technique.

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References

1. Leow JJ, Reese SW, Jiang W, Lipsitz SR, Bellmunt J, Trinh QD, et al. Propensity-matched comparison of morbidity and costs of open and robot-assisted radical cystectomies: a contemporary population-based analysis in the United States. Eur Urol. 2014;66(3):569-76.
2. Smith A, Kurpad R, Lal A, Nielsen M, Wallen EM, Pruthi RS. Cost analysis of robotic versus open radical cystectomy for bladder cancer. J Urol. 2010;183(2):505-9.
3. Hussein AA, Dibaj S, Hinata N, Field E, O'Leary K, Kuvshinoff B, et al. Development and Validation of a Quality Assurance Score for Robot-assisted Radical Cystectomy: A 10-year Analysis. Urology. 2016.
4. Wilson TG, Guru K, Rosen RC, Wiklund P, Annerstedt M, Bochner BH, et al. Best practices in robot-assisted radical cystectomy and urinary reconstruction: recommendations of the Pasadena Consensus Panel. Eur Urol. 2015;67(3):363-75.
5. Azzouni FS, Din R, Rehman S, Khan A, Shi Y, Stegemann A, et al. The first 100 consecutive, robot-assisted, intracorporeal ileal conduits: evolution of technique and 90-day outcomes. Eur Urol. 2013;63(4):637-43.
6. Goh AC, Gill IS, Lee DJ, de Castro Abreu AL, Fairey AS, Leslie S, et al. Robotic intracorporeal orthotopic ileal neobladder: replicating open surgical principles. Eur Urol. 2012;62(5):891-901.
7. Tan WS, Sridhar A, Goldstraw M, Zacharakis E, Nathan S, Hines J, et al. Robot-assisted intracorporeal pyramid neobladder. BJU Int. 2015;116(5):771-9.
8. Tyritzis SI, Hosseini A, Jonsson M, Adding C, Nilsson A, Wiklund NP. Robot-assisted intracorporeal formation of the ileal neobladder. J Endourol. 2012;26(12):1570-5.
9. Hussein AA, Ahmed YE, Kozlowski JD, May PR, Nyquist J, Sexton S, et al. Robot-assisted approach to 'W'-configuration urinary diversion: a step-by-step technique. BJU Int. 2017;120(1):152-7.
10. Jonsson MN, Adding LC, Hosseini A, Schumacher MC, Volz D, Nilsson A, et al. Robot-assisted radical cystectomy with intracorporeal urinary diversion in patients with transitional cell carcinoma of the bladder. Eur Urol. 2011;60(5):1066-73.
11. Ahmed K, Khan SA, Hayn MH, Agarwal PK, Badani KK, Balbay MD, et al. Analysis of intracorporeal compared with extracorporeal urinary diversion after robot-assisted radical cystectomy: results from the International Robotic Cystectomy Consortium. Eur Urol. 2014;65(2):340-7.
12. Smith AB, Raynor M, Amling CL, Busby JE, Castle E, Davis R, et al. Multi-institutional analysis of robotic radical cystectomy for bladder cancer: perioperative outcomes and complications in 227 patients. J Laparoendosc Adv Surg Tech A. 2012;22(1):17-21.
13. Asimakopoulos AD, Campagna A, Gakis G, Corona Montes VE, Piechaud T, Hoepffner JL, et al. Nerve Sparing, Robot-Assisted Radical Cystectomy with Intracorporeal Bladder Substitution in the Male. J Urol. 2016.
14. Collins JW, Sooriakumaran P, Sanchez-Salas R, Ahonen R, Nyberg T, Wiklund NP, et al. Robot-assisted radical cystectomy with intracorporeal neobladder diversion: The Karolinska experience. Indian J Urol. 2014;30(3):307-13.
15. Sim A, Todenhofer T, Mischinger J, Halalsheh O, Fahmy O, Boettge J, et al. Y pouch neobladder-a simplified method of intracorporeal neobladder after robotic cystectomy. J Endourol. 2015;29(4):387-9.
16. Collins JW, Sooriakumaran P, Wiklund NP. Launching and evolving a robotic cystectomy service by developing your 'FORTE'. BJU Int. 2014;113(4):520-2.
17. Hussein AA, Hinata N, Khan N, Rifai SQ, Ahmad N, Hashmi Z, et al. Does Robot-Assisted Approach to Radical Cystectomy Influence Surgeon Choice for Urinary Diversion? J Urol Nephrol Open Access 2016;2(1):1-5.
18. Hussein AA, May PR, Ahmed YE, Saar M, Wijburg CJ, Richstone L, et al. Development of a Patient and Institutional-Based Model for Estimation of Operative Times for Robot-Assisted Radical Cystectomy: Results from the International Robotic Cystectomy Consortium. BJU Int. 2017.

19. Yuh BE, Ciccone J, Chandrasekhar R, Butt ZM, Wilding GE, Kim HL, et al. Impact of previous abdominal surgery on robot-assisted radical cystectomy. JSLS. 2009;13(3):398-405.
20. Eijkemans MJ, van Houdenhoven M, Nguyen T, Boersma E, Steyerberg EW, Kazemier G. Predicting the unpredictable: a new prediction model for operating room times using individual characteristics and the surgeon's estimate. Anesthesiology. 2010;112(1):41-9.
21. Filson CP, Tan HJ, Chamie K, Laviana AA, Hu JC. Determinants of radical cystectomy operative time. Urol Oncol. 2016;34(10):431 e17-24.
22. Hussein AA, May PR, Ahmed YE, Saar M, Wijburg CJ, Richstone L, et al. Development of a patient and institutional-based model for estimation of operative times for robot-assisted radical cystectomy: results from the International Robotic Cystectomy Consortium. BJU Int. 2017;120(5):695-701.
23. Kiran RP, Ahmed Ali U, Coffey JC, Vogel JD, Pokala N, Fazio VW. Impact of resident participation in surgical operations on postoperative outcomes: National Surgical Quality Improvement Program. Ann Surg. 2012;256(3):469-75.
24. Hussein AA, Hashmi Z, Dibaj S, Altartir T, Fiorica T, Wing J, et al. Reoperations following Robot-Assisted Radical Cystectomy: A Decade of Experience. J Urol. 2016;195(5):1368-76.
25. Hautmann RE, de Petriconi RC, Pfeiffer C, Volkmer BG. Radical cystectomy for urothelial carcinoma of the bladder without neoadjuvant or adjuvant therapy: long-term results in 1100 patients. Eur Urol. 2012;61(5):1039-47.
26. Hussein AA, Saar M, May PR, Wijburg CJ, Richstone L, Wagner A, et al. Early Oncologic Failure after Robot-Assisted Radical Cystectomy: Results from the International Robotic Cystectomy Consortium. J Urol. 2017;197(6):1427-36.
27. Dotan ZA, Kavanagh K, Yossepowitch O, Kaag M, Olgac S, Donat M, et al. Positive surgical margins in soft tissue following radical cystectomy for bladder cancer and cancer specific survival. J Urol. 2007;178(6):2308-12; discussion 13.
28. Stein JP, Lieskovsky G, Cote R, Groshen S, Feng AC, Boyd S, et al. Radical cystectomy in the treatment of invasive bladder cancer: long-term results in 1,054 patients. J Clin Oncol. 2001;19(3):666-75.
29. Skinner EC. Choosing the right urinary diversion: patient's choice or surgeon's inclination? Urol Oncol. 2011;29(5):473-5.

Table 1. Demographics, clinical characteristics and perioperative outcomes of patients who underwent ICUD versus ECUD.

Preoperative parameters	**ECUD**	**ICUD**	**All**	**p-value**
N of patients (%)	1031 (49)	1094 (51)	2125	0.17
Age at cystectomy, mean (SD) (yr)	**68 (11)**	**67 (10)**	**67 (11)**	**0.03**
Gender, Males n (%)	**827 (81)**	**780 (71)**	**1607 (76)**	**< 0.001**
Body Mass Index, mean (SD) (kg/m^2)	27.5 (5)	27.3 (5)	27.4 (5)	0.23
ASA score >= 3, mean (SD)	**484 (53)**	**337 (44)**	**821 (49)**	**< 0.001**
Prior abdominal/pelvic surgery, n (%)	375 (41)	264 (45)	639 (43)	0.17
Prior irradiation, n (%)	35 (6)	24 (5)	59 (6)	0.73
Clinical T stage, ≥cT3, n (%)	149 (15)	118 (14)	267 (15)	0.36
Neo-adjuvant chemotherapy, n (%)	**175 (17)**	**254 (25)**	**429 (21)**	**< 0.001**
Perioperative outcomes				
Type of diversion, neobladder, n (%)	236 (23)	231 (21)	467 (22)	0.32
Operative time, median (IQR) (min)	**400 (338-480)**	**357 (297-420)**	**371 (310-450)**	**< 0.001**
Estimated blood loss, median (IQR) (ml)	**350 (200-550)**	**300 (105-500)**	**300 (200-500)**	**< 0.001**
Blood Transfusion, n (%)	**135 (13)**	**50 (5)**	**185 (8)**	**< 0.001**
Postoperative outcomes				
Any complication	**441 (43)**	**623 (57)**	**1064 (50)**	**< 0.001**
Clavien 3-5	**99 (10)**	**141 (13)**	**240 (11)**	**0.02**
30-d complications	**195 (19)**	**335 (31)**	**530 (25)**	**< 0.001**
30-90 d complications	40 (4)	50 (5)	90 (4.2)	0.43
Any readmission	**147 (34)**	**213 (26)**	**360 (29)**	**0.003**
0-30-d readmissions, n (%)	56 (5)	57 (5)	113 (5.3)	0.82
30-90-d readmissions, n (%)	34 (3)	46 (4)	80 (3.8)	0.27
90-d mortality, n (%)	27 (3)	27 (3)	54 (3)	0.73
Adjuvant chemotherapy, n (%)	**156 (21)**	**116 (13)**	**272 (16)**	**< 0.001**
Hospital stay, median (IQR) (days)	**8 (6-12)**	**9 (7-14)**	**9 (7-13)**	**< 0.001**
Intensive Care Unit stay, median (IQR) (days)	**0 (0-1)**	**1 (0-1)**	**1 (0-1)**	**< 0.001**
Follow up, median (months) (IQR)	**17 (7-32)**	**11 (4-25)**	**13 (5-29)**	**< 0.001**

Table 2. Pathologic outcomes and sites of disease relapse

Pathological outcomes	**ECUD**	**ICUD**	**All**	**p-value**
Pathologic T stage, ≥pT3, n (%)	372 (39)	391 (38)	763 (39)	0.59
Lymph node yield, mean	19 (12)	18 (11)	18 (11)	0.90
N positive, n (%)	198 (19)	198 (18)	396 (19)	0.51
Positive surgical margins, n (%)	74 (7)	74 (7)	148 (7)	0.71
Any recurrence, n (%)	**244 (24)**	**204 (19)**	**448 (19)**	**0.005**
Recurrence Site	**ECUD**	**ICUD**	**All**	**p-value**
Local recurrence, n (%)	101 (10)	107 (10)	208 (10)	1.00
Pelvis	43 (4)	47 (4)	90 (4)	0.91
Vagina	1 (0.1)	3 (0.3)	4 (0.3)	0.63
Rectum	8 (0.8)	7 (0.6)	15 (0.6)	0.80
Perineum	3 (0.3)	10 (0.9)	13 (0.9)	0.09
Urethra	7 (0.7)	2 (0.2)	9 (0.2)	0.10
Penile	0 (0)	2 (0.2)	2 (0.2)	0.50
Neobladder/Conduit	1 (0.1)	3 (0.3)	4 (0.3)	0.63
Kidney	1 (0.1)	3 (0.3)	4 (0.3)	0.63
Multiple Local	8 (0.8)	13 (1)	21 (1)	0.39
Unidentified site	42 (4)	29 (3)	71 (3)	0.07
Distant recurrence, n (%)	**188 (18)**	**151 (14)**	**339 (14)**	**0.005**
Nodal	**14 (1)**	**33 (3)**	**47 (3)**	**0.01**
Lung	36 (4)	38 (4)	74 (4)	1.00
Liver	16 (2)	18 (2)	34 (2)	1.00
Bone	24 (2)	34 (3)	58 (3)	0.29
Brain	1 (0.1)	6 (0.5)	7 (0.5)	0.13
Abdominal wall	3 (0.3)	4 (0.4)	7 (0.4)	1.00
Multiple distant	**14 (1)**	**29 (3)**	**43 (2.7)**	**0.04**
Unidentified site	**111 (11)**	**58 (5.3)**	**169 (5.3)**	**<0.001**
Peritoneal carcinomatosis	**3 (0.3)**	**14 (1.3)**	**17 (1.3)**	**0.01**
Port-site recurrence	0 (0)	3 (0.3)	3 (0.3)	0.25

Table 3. Stepwise multivariable logistic regression modeling predictors for receiving ICUD

Parameter	Odds Ratio	95% Confidence Interval	p-value
Annual RARC volume	1.02	(1.01, 1.03)	0.002
Cystectomy Era (2009-2012) vs (2005-2008)	7.95	(5.6, 11.4)	< 0.001
Cystectomy Era (2013-2016) vs (2005-2008)	67.8	(43.8, 105)	< 0.001
ASA < 3	1.75	(1.38, 2.22)	< 0.001

Table 4. Stepwise multivariable linear regression modeling predictors for longer operative time

Parameter	Estimate (min)	p-value
Intercept	376	<0 .001
Age at Cystectomy	-1	<0.001
Body Mass Index	4	<0.001
ASA ≥ 3	22	<0.001
Average Cyst per Year	-1	<0.001
Cystectomy Era (2013-2016) [2005-2008]	-23	0.01
Neobladder	64	<0.001
ICUD	-27	<0.001

Table 5. Stepwise multivariable regression modeling predictors for high grade complications and any readmission

High grade complications	**Odds Ratio**	**95% Confidence Interval**	**p-value**
Previous Abdominal Surgery	1.52	(1.08, 2.15)	0.02
Any readmission	**Odds Ratio**	**95% Confidence Interval**	**p-value**
Body Mass Index	1.05	(1.02, 1.07)	0.0002
Clavien 3-5	2.22	(1.56, 3.15)	< 0.0001

Table 6. Multivariable Cox proportional hazards modelling predictors of OS.

RFS	**Hazard Ratio**	**95% Confidence Interval**	**p-value**
Cystectomy era (2009-2013)	0.72	(0.57, 0.92)	0.03
Cystectomy era (2013-2017)	0.85	(0.62, 1.18)	0.32
pN+	2.72	(1.81, 2.86)	<0.001
≥pT3	3.51	(2.76, 4.45)	< 0.001
DSS	**Hazard Ratio**	**95% Confidence Interval**	**p-value**
Lymph node yield	0.97	(0.96, 0.99)	0.01
Positive margins	1.66	(1.07, 2.56)	0.02
pN+	2.18	(1.58, 3.01)	<0.001
≥pT3	5.63	(3.89, 8.13)	< 0.001
OS	**Hazard Ratio**	**95% Confidence Interval**	**p-value**
BMI	0.97	(0.95, 0.99)	0.003
High grade complications	1.55	(1.14, 2.11)	0.006
ASA≥3	1.36	(1.10, 1.70)	0.005
Neobladder	0.49	(0.30, 0.70)	<0.001
Positive margins	1.46	(1.06, 2.00)	0.02
pN+	1.78	(1.39, 2.29)	<0.001
≥pT3	3.52	(2.73, 4.54)	< 0.001

Figure 1: Diversion approach by year. ICUD increased from 9% in 2005 to 97% in 2015. Increase of 11% per year ($p < 0.001$)

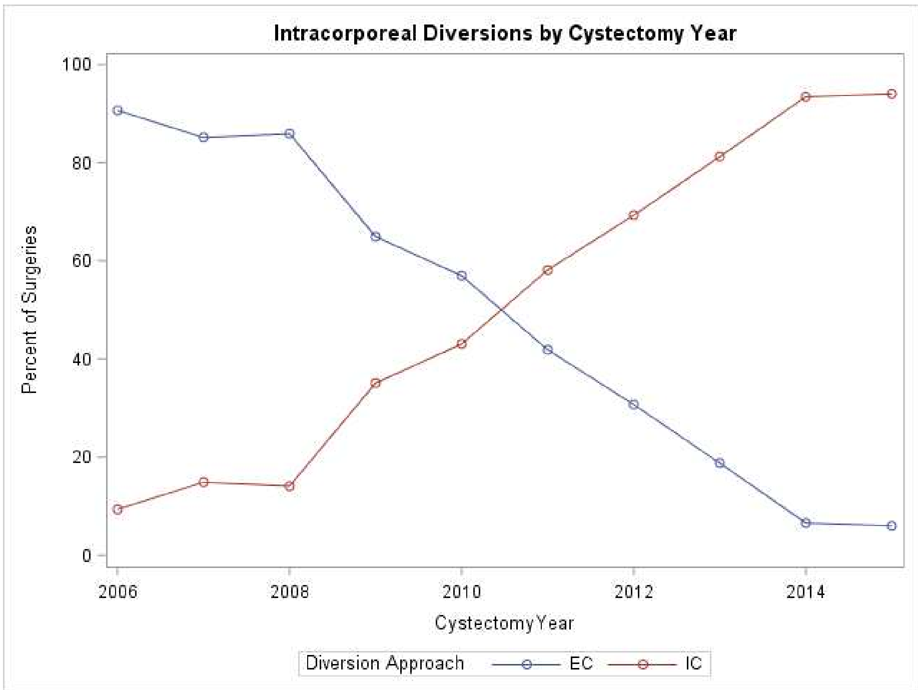


Figure 2: Diversion type and approach by year

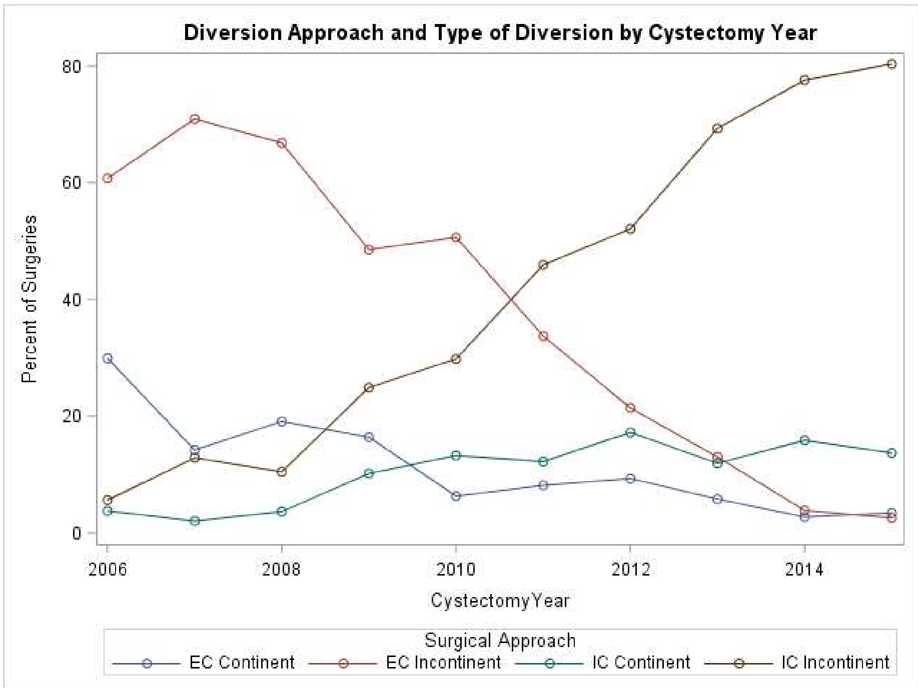


Figure 3: Diversion Approach by Region

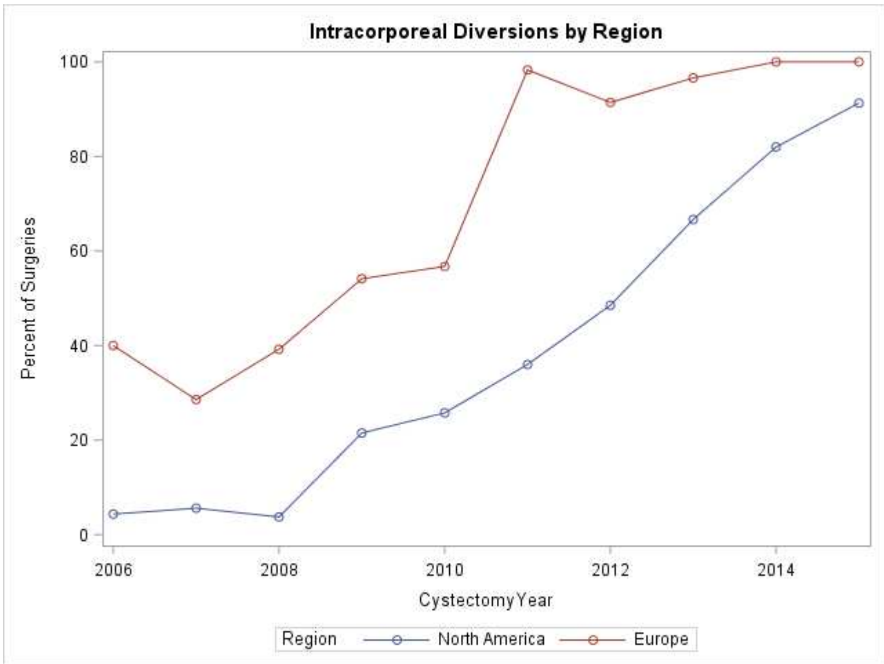


Figure 4: High grade complications after ICUD decreased from 25% in 2005 to 6% in 2015 (decrease of 2%/year, p<0.001). For ECUD, they remained stable (13% in 2006 to 14% in 2015 (p =0.76).

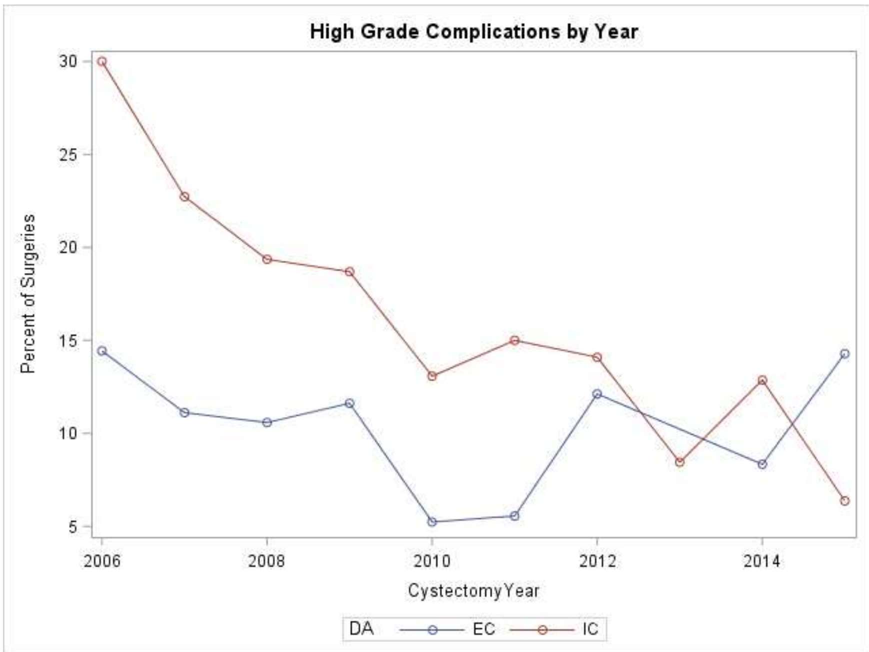
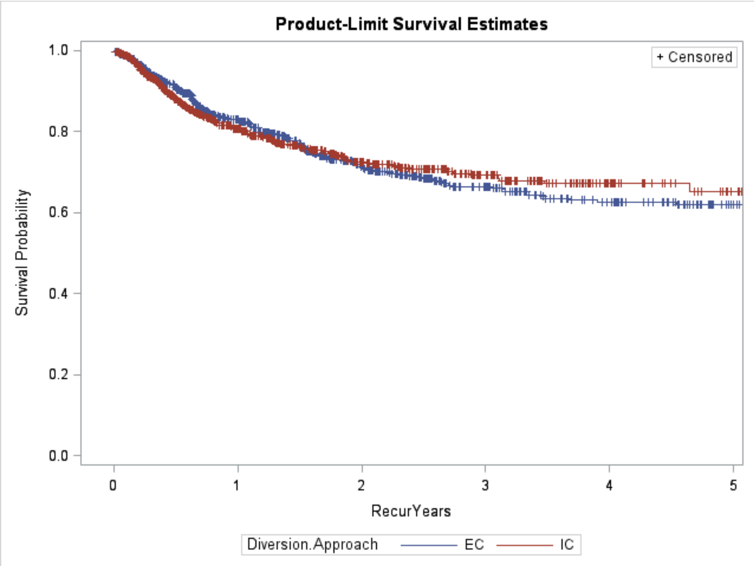


Figure 5: A. Kaplan Meier curves depicting RFS for patients who received ICUD vs ECUD after RARC (log rank p=0.97)



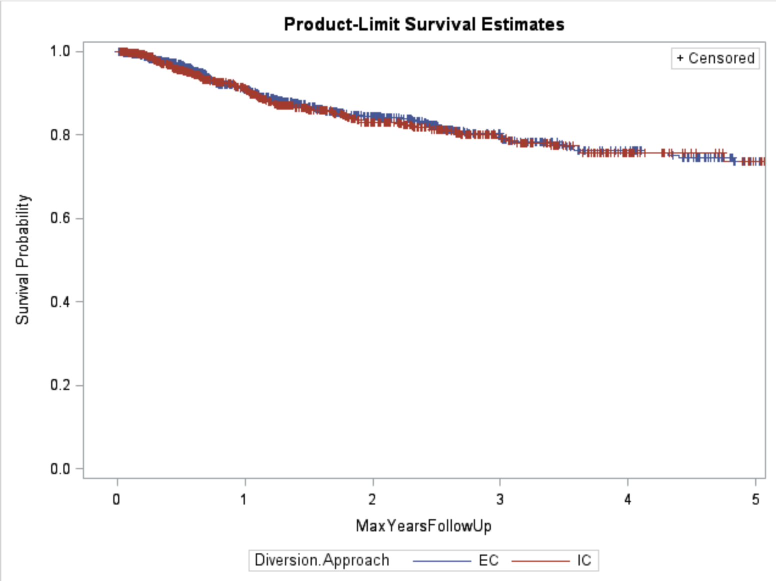
IC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	152	439	818.5	1	0
1	2	35	166	364	0.81	0.19
2	3	9	116	188	0.74	0.26
3	4	3	65	88.5	0.70	0.30
4	5	1	27	39.5	0.68	0.32
5	.	2	23	13.5	0.66	0.34

EC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	128	272	770	1	0
1	2	62	130	441	0.84	0.16
2	3	17	115	256.5	0.72	0.28
3	4	9	45	159.5	0.67	0.33
4	5	1	46	105	0.63	0.37
5	.	5	76	43	0.63	0.37

B. Kaplan Meier curves depicting DSS for patients who received ICUD vs ECUD after RARC (log rank p=0.80)



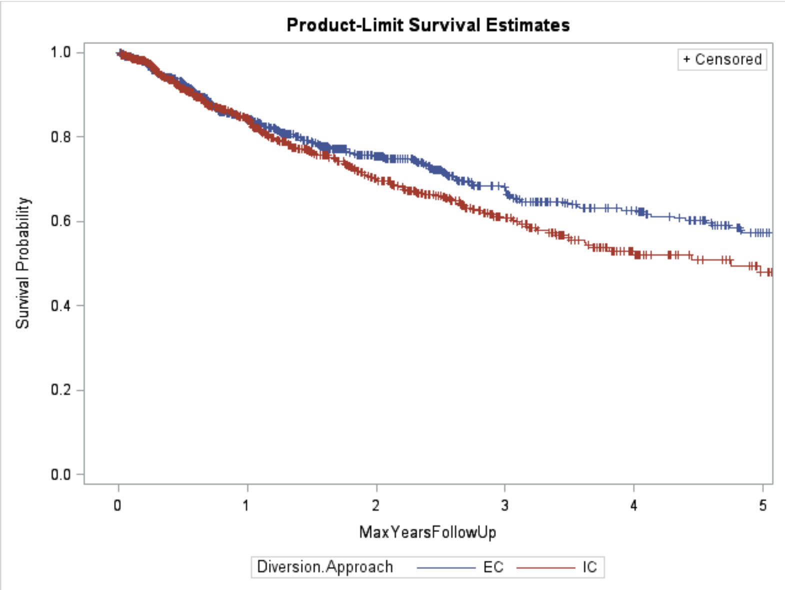
IC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	65	472	802	1	0
1	2	36	191	405.5	0.92	0.08
2	3	9	132	208	0.84	0.16
3	4	5	70	98	0.80	0.20
4	5	1	29	43.5	0.76	0.24
5	.	0	28	14	0.74	0.26

EC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	64	301	755.5	1	0
1	2	33	162	460	0.92	0.08
2	3	14	131	280.5	0.85	0.15
3	4	9	53	174.5	0.81	0.19
4	5	4	45	116.5	0.77	0.23
5	.	4	86	47	0.74	0.26

C. Kaplan Meier curves depicting OS for patients who received ICUD vs ECUD after RARC (log rank p=0.046)



IC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	123	414	831	1	0
1	2	70	157	422.5	0.85	0.15
2	3	28	113	217.5	0.71	0.29
3	4	15	60	103	0.62	0.38
4	5	3	27	44.5	0.53	0.47
5	.	1	27	14.5	0.49	0.51

EC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	119	246	783	1	0
1	2	50	145	468.5	0.85	0.15
2	3	26	119	286.5	0.76	0.24
3	4	15	47	177.5	0.69	0.31
4	5	10	39	119.5	0.63	0.37
5	.	17	73	53.5	0.58	0.42

Supplementary Table 1: RARCs/institution/year

Institution	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
1	0	0	0	0	3	26	13	9	9	8	11	0	79
2	0	0	2	2	8	2	0	0	0	0	0	0	14
3	0	0	0	0	0	0	0	2	11	0	0	0	13
4	2	16	1	2	11	5	11	7	37	0	0	0	92
5	16	16	8	22	16	4	0	0	0	0	0	0	82
6	0	0	1	12	2	0	0	0	0	0	0	0	15
7	0	0	0	0	0	2	0	0	0	0	0	0	2
8	0	0	1	8	9	8	0	0	0	0	0	0	26
9	6	4	9	16	41	38	0	0	0	0	0	0	114
10	3	5	16	8	13	3	8	14	4	0	0	0	74
11	1	5	2	8	19	19	15	48	84	43	0	0	244
12	0	0	0	0	0	0	2	8	6	2	0	0	18
13	0	0	0	0	0	5	0	0	0	0	0	0	5
14	0	0	0	0	0	0	1	0	0	0	0	0	1
15	0	0	0	1	0	5	7	7	2	0	0	0	22
16	12	6	15	14	4	1	0	0	0	0	0	0	52
17	0	0	0	0	0	2	16	19	25	36	23	0	121
18	3	30	33	47	42	44	36	45	45	45	46	36	452
19	0	0	0	0	0	0	5	15	33	41	34	0	128
20	0	0	8	5	36	36	21	15	0	3	3	0	127
21	0	0	3	3	25	13	0	0	0	0	0	0	44
22	0	4	4	3	7	3	0	0	0	0	0	0	21
23	0	21	31	32	24	29	18	25	21	5	0	0	206
24	0	0	0	18	29	42	19	1	0	0	0	0	109
25	0	0	8	11	9	10	0	0	0	0	0	0	38
26	0	0	6	8	7	5	0	0	0	0	0	0	26
Total	43	107	148	220	305	302	172	215	277	183	117	36	2125

Supplementary Table 2: Comorbidities of patients who underwent ECUD vs ICUD

Variable Name	EC	IC	All (n)	All (%)	P Value
Number of Patients	1031 (48.52)	1094 (51.48)	2125		0.172
Myocardial Infarction	42 (10.99)	43 (6.96)	85	8.5	0.026
Arrhythmia	40 (8.64)	45 (7.27)	85	7.86	0.407
Congestive Heart Failure	10 (2.62)	44 (7.12)	54	5.4	0.002
Peripheral Vascular Disease	20 (5.28)	39 (6.39)	59	5.97	0.471
Carotid Disease	9 (2.37)	24 (4.04)	33	3.39	0.162
Cardiovascular Disease	129 (22.87)	131 (21.41)	260	22.11	0.545
Renal Insufficiency	27 (7.07)	61 (9.89)	88	8.81	0.127
Dementia	2 (0.53)	7 (1.15)	9	0.91	0.495
Asthma	13 (3.44)	26 (4.29)	39	3.96	0.506
COPD	74 (13.17)	81 (13.28)	155	13.23	0.955
Arthritis	49 (13)	60 (9.88)	109	11.08	0.13
Peptic Ulcer Disease	24 (6.37)	31 (5.13)	55	5.61	0.414
Diabetes Mellitus	149 (19.33)	135 (21.74)	284	20.4	0.267
Stroke	20 (5.31)	20 (3.29)	40	4.06	0.119
Liver Disease	45 (9.34)	13 (2.13)	58	5.32	< 0.001
DVT/PE	12 (3.18)	34 (5.59)	46	4.67	0.082
Hypertension	400 (59.88)	331 (53.56)	731	56.84	0.022

Key of Definitions:

- Robot-assisted radical cystectomy (RARCs)
- Intracorporeal urinary diversion (ICUD)
- Extracorporeal urinary diversion (ECUD)
- International Robotic Cystectomy Consortium (IRCC).
- Body mass index [BMI],
- American Society of Anesthesiologists [ASA]
- Recurrence-free (RFS), disease specific (DSS) and overall survival (OS)
- Odds ratio [OR]
- 95% Confidence Interval [CI]

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